R E P O R T R E S U M E S

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AUTOMOTIVE DIESEL MAINTENANCE 1. UNIT XXIV, I--MAINTAINING THE FUEL SYSTEM PART III--CATERPILLAR DIESEL ENGINE, II--UNDERSTANDING THE VOLTAGE REGULATOR/ALTERNATOR.

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THIS MODULE OF A 30-MODULE COURSE IS DESIGNED TO DEVELOP AN UNDERSTANDING OF THE OPERATION AND MAINTENANCE OF THE DIESEL ENGINE FUEL AND BATTERY CHARGING SYSTEM. TOPICS ARE (1) INJECTION TIMING CONTROLS, (2) GOVERNOR, (3) FUEL SYSTEM MAINTENANCE TIPS, (4) THE CHARGING SYSTEM, (5) REGULATING THE GENERATOR/ALTERNATOR, AND (6) CHARGING SYSTEM SERVICE PRECAUTIONS. THE MODULE CONSISTS OF A SELF-INSTRUCTIONAL BRANCH PROGRAMED TRAINING FILM "UNDERSTANDING THE CATERPILLAR FUEL SYSTEM" AND OTHER MATERIALS. SEE VT 005 655 FOR FURTHER INFORMATION. MODULES IN THIS SERIES ARE AVAILABLE AS VT 005 655 - VT 005 684. MODULES FOR "AUTOMOTIVE DIESEL MAINTENANCE 2" ARE AVAILABLE AS VT 005 685 - VT 005 709. THE 2-YEAR PROGRAM OUTLINE FOR "AUTOMOTIVE DIESEL MAINTENANCE 1 AND 2" IS AVAILABLE AS VT 006 006. THE TEXT MATERIAL, TRANSPARENCIES, PROGRAMED TRAINING FILM, AND THE ELECTRONIC TUTOR MAY BE RENTED (FOR $1.75 PER WEEK) OR PURCHASED FROM THE HUMAN ENGINEERING INSTITUTE, HEADQUARTERS AND DEVELOPMENT CENTER, 2341 CARNEGIE AVENUE, CLEVELAND, OHIO 44115. (HC)

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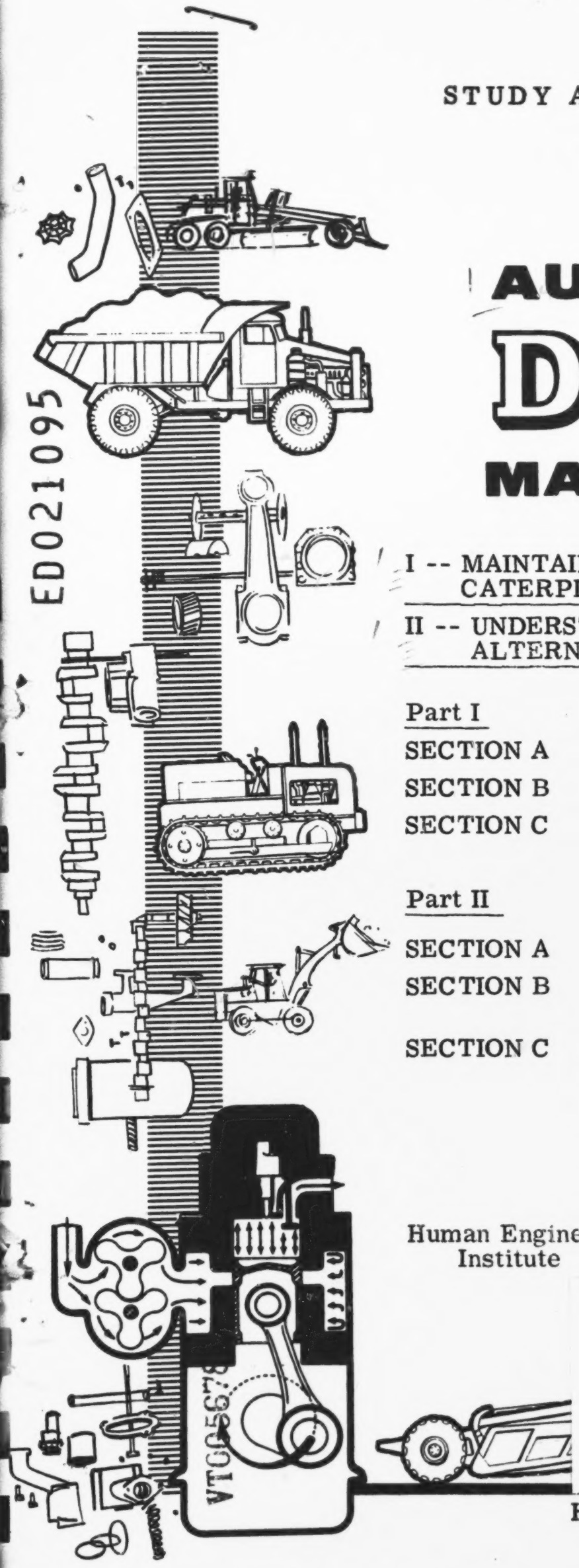

STUDY AND READING MATERIALS

AUTOMOTIVE DIESEL MAINTENANCE 1

I -- MAINTAINING THE FUEL SYSTEM PART III -- CATERPILLAR DIESEL ENGINE

II -- UNDERSTANDING THE VOLTAGE REGULATOR/ ALTERNATOR

UNIT XXIV

Part I

SECTION A	INJECTION TIMING CONTROLS
SECTION B	GOVERNOR
SECTION C	FUEL SYSTEM MAINTENANCE TIPS

Part II

SECTION A	THE CHARGING SYSTEM
SECTION B	REGULATING THE GENERATOR/ ALTERNATOR
SECTION C	CHARGING SYSTEM SERVICE PRECAUTIONS

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This unit is divided into two parts. The first part completes the story of the CAT fuel system. The second part is a brief presentation of the charging system, voltage regulator/alternator.

I -- MAINTAINING THE FUEL SYSTEM PART III --CATERPILLAR DIESEL ENGINE

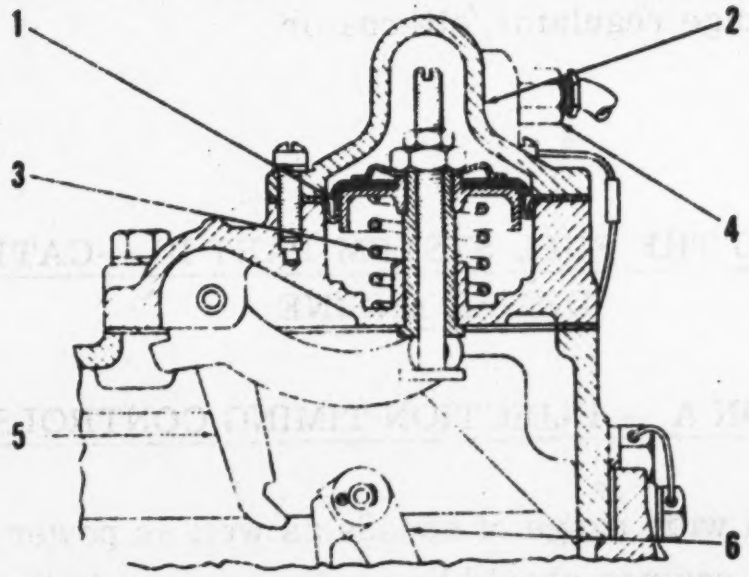
SECTION A -- INJECTION TIMING CONTROLS

When operating over a wide range of speeds as well as power, injection timing on many diesel engines should be varied to provide the best operation from standpoints of power, smoothness, and economy. The need increases as engine operating speeds are raised and the amount of advance required can exceed that possible by rotating the helix in the pump plungers.

Special couplings are available and they achieve the automatic advance. One such device used by MACK TRUCKS, INC. and called a "Synchro-vance" provides a variable - angle coupling between the injection pump and the injection pump drive and automatically advances timing of the injection pump beyond the static setting as speed of the engine increases.

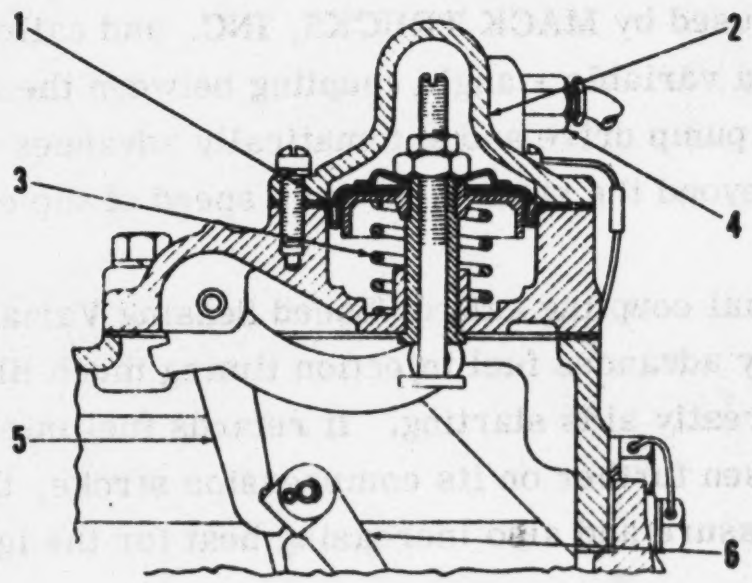
CAT uses a special coupling called "Speed Sensing Variable Timing Unit" that automatically advances fuel injection timing much like the Mack unit. The unit greatly aids starting. It retards fuel injection until the piston has risen further on its compression stroke, thereby increasing compression pressure and also increasing heat for the ignition at the time of injection.

THE RACK LIMITER -- The Rack Limiter on the CAT engine serves about the same purpose as the "ANEROID" valve on the Cummins engine, and works about the same way.



1-Diaphragm. 2-Chamber. 3-Spring. 4-Fitting.
5-Bellcrank. 6-Linkage.

Fig. 1 Rack Limiter (engine not running) (limiter inoperative)



1-Diaphragm. 2-Chamber. 3-Spring. 4-Fitting.
5-bellcrank. 6-Linkage.

Fig. 2 Rack Limiter (engine under acceleration) (limiter restricting fuel rack opening.)

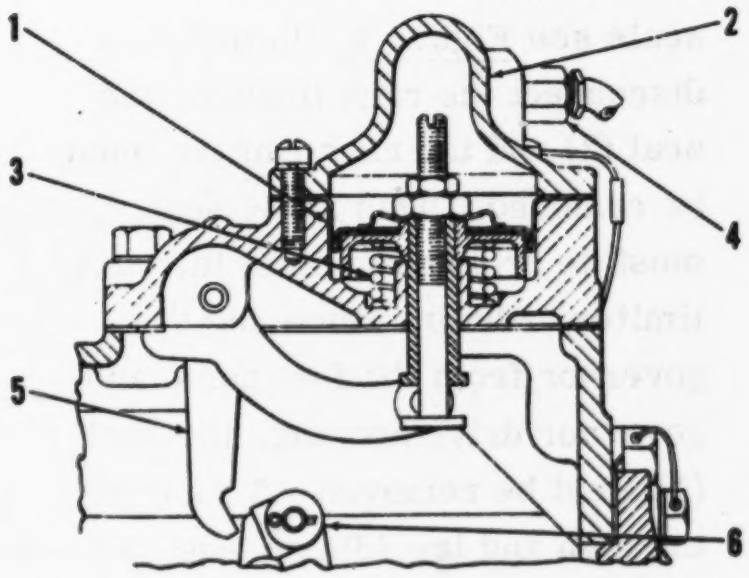
A rack limiter is mounted on top of the governor housing. When the engine is operating, inlet manifold pressure is applied to the chamber above the diaphragm, see Figure 1(1), through a tube connected between the inlet manifold and fitting, see Figure 1(4).

The primary purpose of the rack limiter is to remedy this condition by limiting the rack movement until sufficient manifold pressure boost is available to supply adequate air to the engine for effieicnt combustion. The chamber (2) in the rack limiter cover is connected to the diesel engine inlet manifold.

The spring (3) opposes the force exerted on top of the diaphragm (1) by the inlet manifold pressure. If the inlet manifold pressure is too low to provide an efficient fuel-air mixture, the bellcrank (5) contacts the linkage (6) to the fuel rack, and limits the fuel rack travel (see Figure 2). This reduces the amount of exhaust smoke, which indicates unburned fuel, and allows the engine to operate more efficiently. The rack limiter does not reduce the power or rate of acceleration of the engine if it is properly adjusted.

As the speed of the turbocharger increases, the inlet manifold pressure increases, depressing the diaphragm against the force of the spring. This action pushes the bellcrank away from the fuel rack linkage and allows the governor to assume full control. This position of the mechanism is shown in Figure 3.

Any substantial variation of inlet manifold pressure is transferred through the rack limiter to the bellcrank and to the fuel rack.



1-Diaphragm. 2-Chamber. 3-Spring. 4-Fitting. 5-Bellcrank. 6-Linkage.

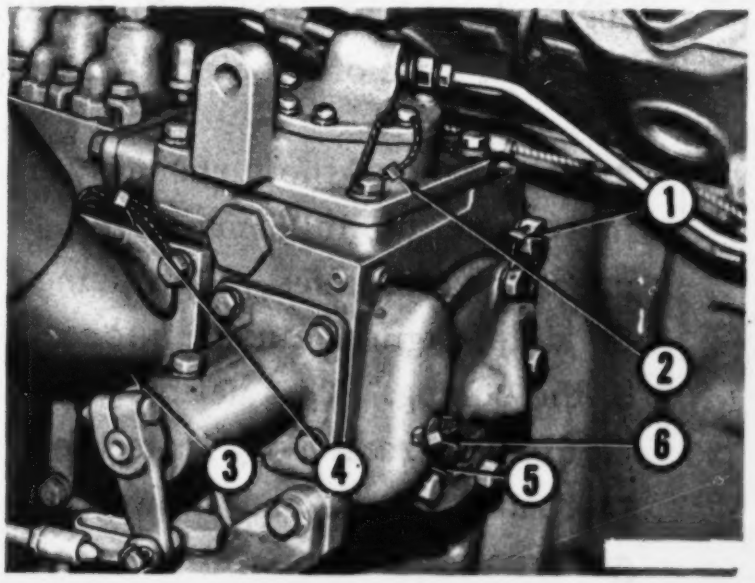
Fig. 3 Rack Limiter (engine under full load) (Governor has full control).

As was mentioned before, the rack limiter on CAT engines serves about the same purpose as the ANEROID valve on CUMMINS engines. The ANEROID control is a fuel by-pass system that responds to inlet air manifold pressure. The ANEROID limits fuel manifold pressure when the inlet manifold pressure is low. When accelerating from speeds below normal operating range, manifold air pressure is not sufficient to support combustion. The ANEROID by-passes part of the fuel, reducing fuel manifold pressure to a value which will not produce heavy smoke during the transitional period from low to high speed.

SECTION B -- GOVERNOR

LOCATION -- The governor is located on the right side of the engine and is mounted on the front face of the fuel injection pump housing. It is driven by a gear on the fuel injection pump camshaft.

GOVERNOR SEALS -- The covers and governor mounting belts are sealed with wire and aluminum seals see Figure 4. In order to disconnect the rack linkage, the seal (2) and the rack limiter must be removed. This same seal must be broken to adjust the rack limiter. Before removing the governor from the fuel pump and governor drive housing, the seal (1) must be removed. To adjust the high and low idle speeds, the cover (5) and seal (6) must be removed. In order to adjust the rack setting, both the seal (4) and the oil filler pipe (3) must be removed.



1-Seal. 2-Seal. 3-Oil filler pipe. 4-Seal. 5-Cover. 6-Seal.

Fig. 4 Governor seals.

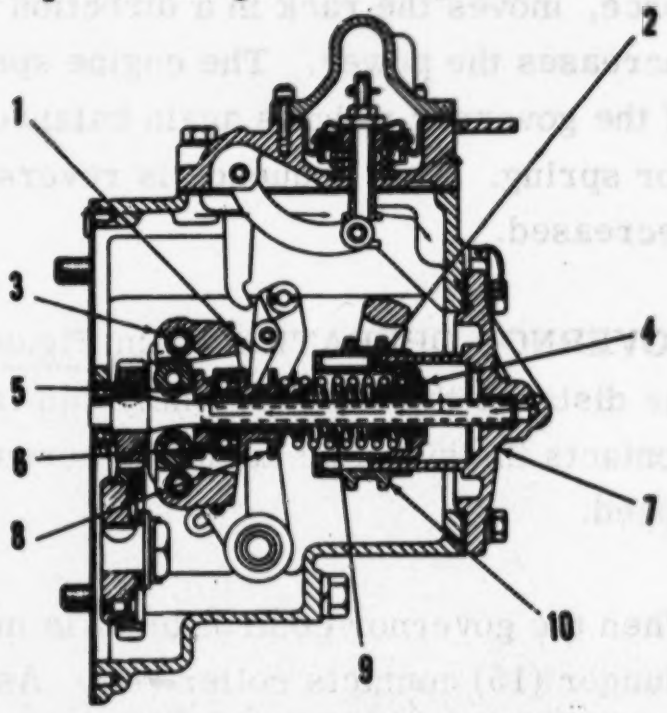
Rack settings are carefully set at the factory and should not be changed without specific instructions to do so. An incorrectly adjusted fuel rack affects the operation of the turbocharger.

Factory installed seals are identified by the letters "CTCo". Dealer's sealing tool assembly will impress the letters DLR on the seals.

GOVERNOR FUNCTION -- The operator selects a desired engine speed by depressing the foot accelerator. The governor maintains this speed nearly constant even though the load varies.

Linkage which controls the governor also actuates a servo mechanism to reduce the effort required on the foot accelerator. A hydraulic boost is provided by engine lubricating oil to compress the governor spring.

See Figure 5, governor cross section.
As the foot accelerator is depressed, linkage connecting it to the serve cylinder moves the cylinder (10) against the piston (4), which in turn uncovers the oil passage in the governor spindle (9). The incoming oil fills the space between the cylinder (10) and the piston (4). The trapped oil exerts pressure against the piston and compresses the governor springs (2).



1-Fuel pump rack assembly. 2-Springs (two). 3-Weight. 4-Piston assembly. 5-Sleeve assembly. 6-Bearing. 7-Cover. 8-Cage. 9-Spindle. 10-Cylinder.

Fig. 5 Governor cross section (right side view)

If the accelerator pedal movement stops, the servo cylinder movement also stops. However, the oil pressure forces the piston slightly farther against the springs (2), allowing the trapped oil to be relieved through the space between the piston (4) and cylinder (10). The sequence is repeated at each

increased engine speed setting up to full load speed. At low idle engine speeds, the piston (4) covers the oil inlet hole and the servo mechanism is not effective.

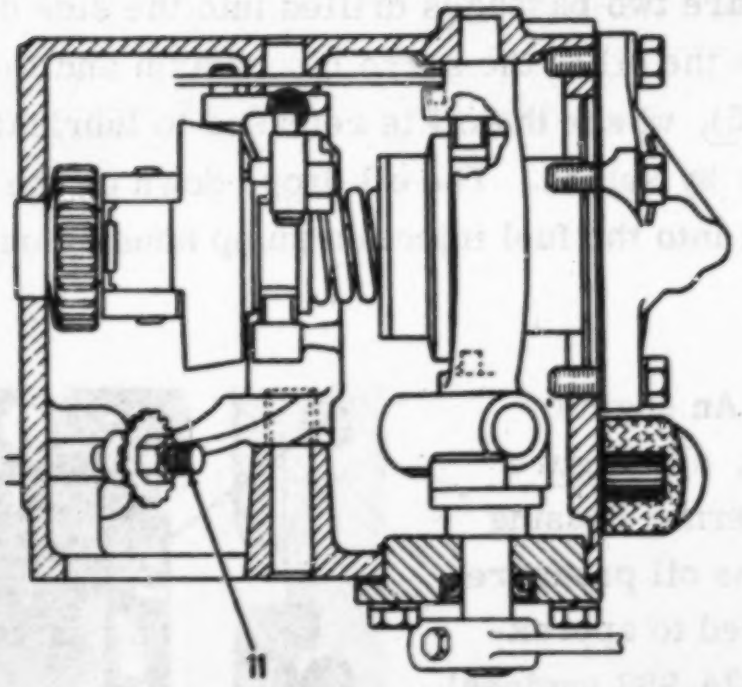
The centrifugal force of the governor weights (3) acting through the sleeve assembly (5), bearing (6) and the cage (8) opposes the force created by the compression on the governor springs (2). These forces always tend to balance. These balanced forces hold the fuel pump rack assembly (1), which controls the amount of fuel delivered into the engine, in such a position to make the engine operate at a constant speed.

When the engine encounters a load, the speed decreases. The centrifugal force of the governor weights decreases. The spring, opposed by a lesser force, moves the rack in a direction to give the engine more fuel which increases the power. The engine speed will then increase until the force of the governor weights again balances the force of the compressed governor spring. This sequence is reversed when the load on the engine is decreased.

GOVERNOR OPERATION -- In Figure 6, the adjusting screw (11) limits the distance the rack assembly can travel. In Figure 7, the stop (13) contacts the high idle adjusting screw (12) to control the engine high idle speed.

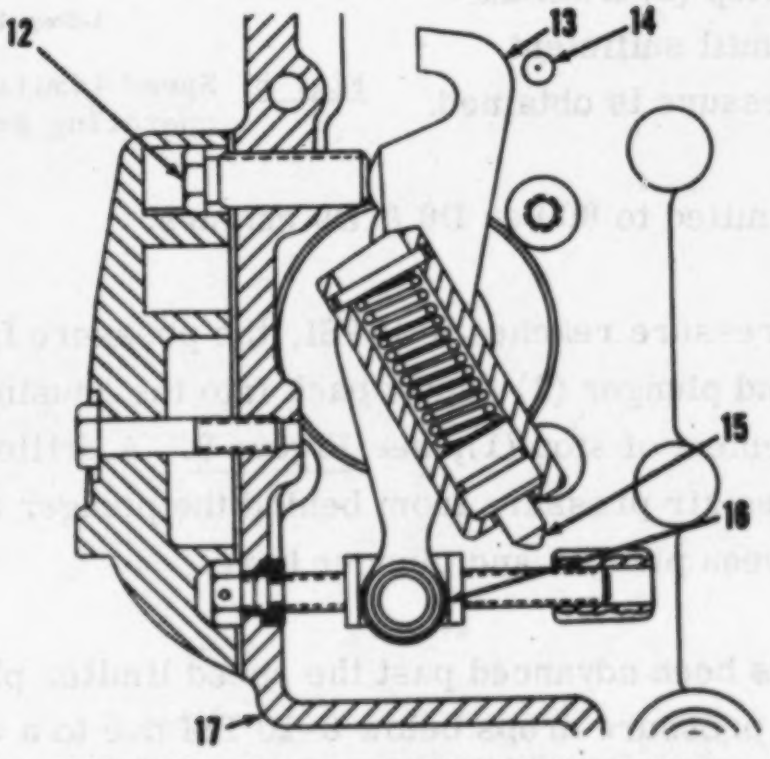
When the governor control level is moved to the LOW IDLE position, plunger (15) contacts roller (16). As the control lever is moved still farther to decrease the engine speed, plunger (15) compresses the spring which permits the plunger to move past roller (16), thus moving the fuel pump rack to the SHUT-OFF position to stop the engine.

LUBRICATION -- The governor is lubricated by oil from the engine lubricating system. Oil from the diesel engine oil manifold is directed to a passage in the fuel injection pump housing which mates with a drilled passage in cover, Figure 5 (7), from the drilled passage in the governor



11-Adjusting screw.

Fig. 6 Governor Cross Section (top view).

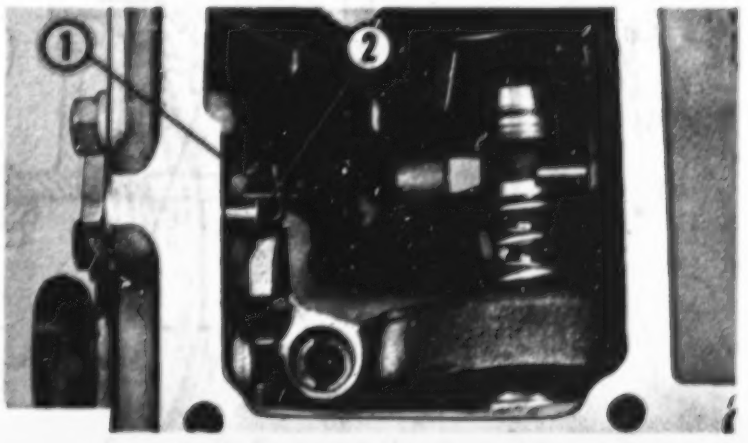


12-High idle adjusting screw. 13-Stop. 14-Speed limiter plunger. 15-Plunger. 16-Roller. 17-Governor housing.

Fig. 7 Governor Cross Section (partial left side view).

housing and then directed into a drilled passage in governor spindle, Figure 5(9). There are two passages drilled into the side of the governor spindle which directs the oil to the servo mechanism and to the sleeve assembly, Figure 5(5), where the oil is released to lubricate the various parts of the governor by splash. The oil drops down on the governor drive gear and drains back into the fuel injection pump housing on its way to the engine oil pan.

SPEED LIMITER -- An engine speed limiter device, see Figure 8, located in the governor housing and actuated by engine oil pressure, limits the engine speed to approximately 1160 RPM (824,988 engines) until the oil pressure reaches 8-10 PSI. A spring forces plunger (2) out and prevents stop (1) from advancing the rack until sufficient lubricating oil pressure is obtained.



1-Stop. 2-Plunger.

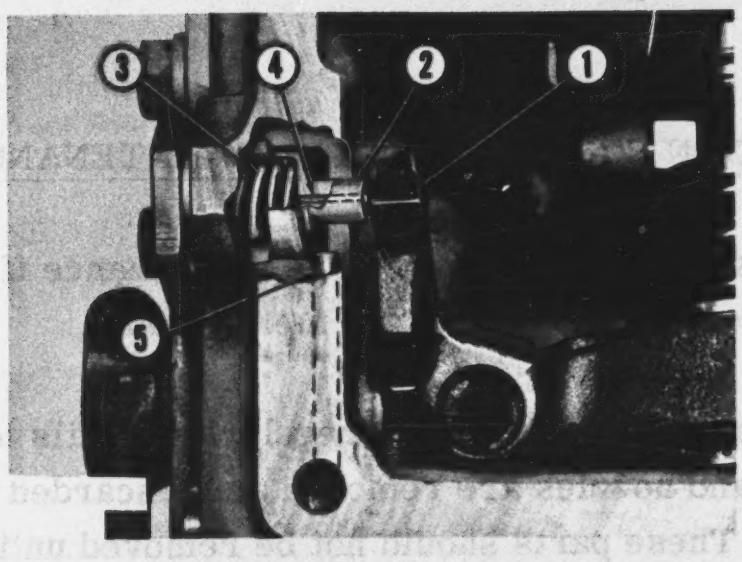
Fig. 8 Speed Limiter - below operating pressure.

NOTE: RPM is limited to 800 on D8 & D9 engines.

When engine oil pressure reaches 8-10PSI, the pressure from spring (3) is overcome and plunger (2) moves back into the housing allowing unrestricted movement of stop (1), see Figure 9. A drilled hole (4) in plunger (2) relieves air pressure from behind the plunger and vents oil that leaks between plunger and plunger bore.

When the lever has been advanced past the speed limiter plunger and engine system oil pressure drops below 8-10 PSI due to a damaged lubrication system, the speed limiter will not function until stop (1) is returned to the LOW IDLE position and moved forward again.

The service meter and tachometer drive assembly, see Figure 10, is



1-Stop. 2-Plunger. 3-Spring. 4-Drilled hole.
5-Oil supply passage.

Fig. 9 Speed limiter - operating pressure.

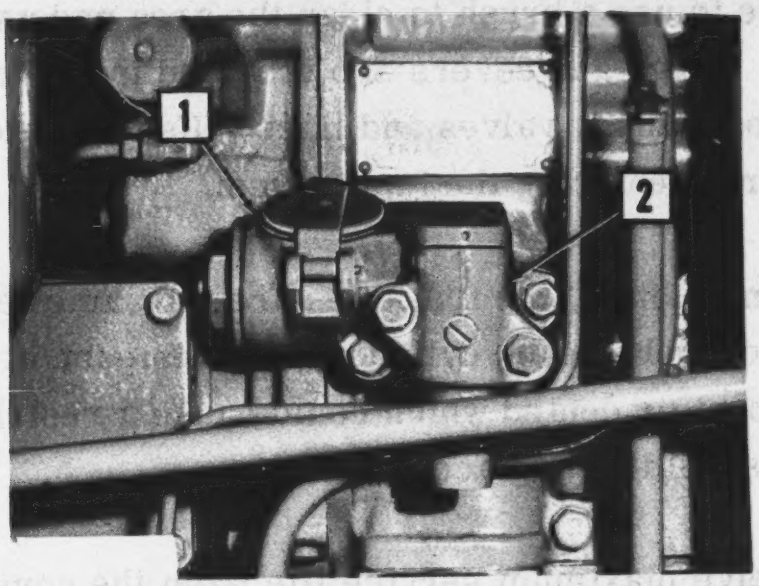


Fig. 10 Service meter & tachometer drive.

located on the side of the fuel injection pump housing and is driven by the fuel injection pump camshaft. The Service Meter provides an accurate means of determining time periods for lubrication and maintenance.

SECTION C -- FUEL SYSTEM MAINTENANCE TIPS

The injection system requires very little maintenance if scheduled maintenance is practiced on the rest of the fuel system.

Many times, when the engine fires irregularly or fails to start, the injection pumps and nozzles are removed and discarded when the fault lies elsewhere. These parts should not be removed until all other possible causes have been eliminated. If the pumps and nozzles are removed frequently, there is more chance for water and abrasives to enter the system. If it does become necessary to remove components of the fuel system, be sure to use a brush to clean the area and use clean wrenches to do the work. Plugs and covers are provided in the tool equipment to seal the injection pumps, valves and lines. Use them to prevent water and abrasives from entering the fuel system.

As previously mentioned, the fuel lines are the same length to provide a uniform flow of fuel to each cylinder. It is important that these lines do not become bent or dented which could cause a restriction in fuel flow. Damaged lines should be replaced.

In order to receive maximum service life from the component parts of the fuel system, follow these practices.

Use clean fuel and keep it clean.

Change fuel filters when the fuel pressure gage reads "Out," with the engine running, and always drain and flush the filter housing before installing new Caterpillar fuel filter element.

Drain sediment and water from the filter housing and fuel tank regularly. Condensation in a fuel tank can be reduced by filling the tank at the end of a shift.

II -- UNDERSTANDING THE VOLTAGE REGULATOR/ALTERNATOR

SECTION A -- THE CHARGING SYSTEM

FUNCTION -- As has been mentioned before the generator/alternator is a device that converts mechanical energy from the engine into electrical energy. The generator replaces in the battery the current used in electrical devices, lights, heater, etc. The generator or alternator is usually mounted on the side of the engine block or, on some V-type engines, between the two banks of cylinders. It is normally driven by the fan belt, except some gear driven units. Figure 11 shows a schematic of a typical charging system.

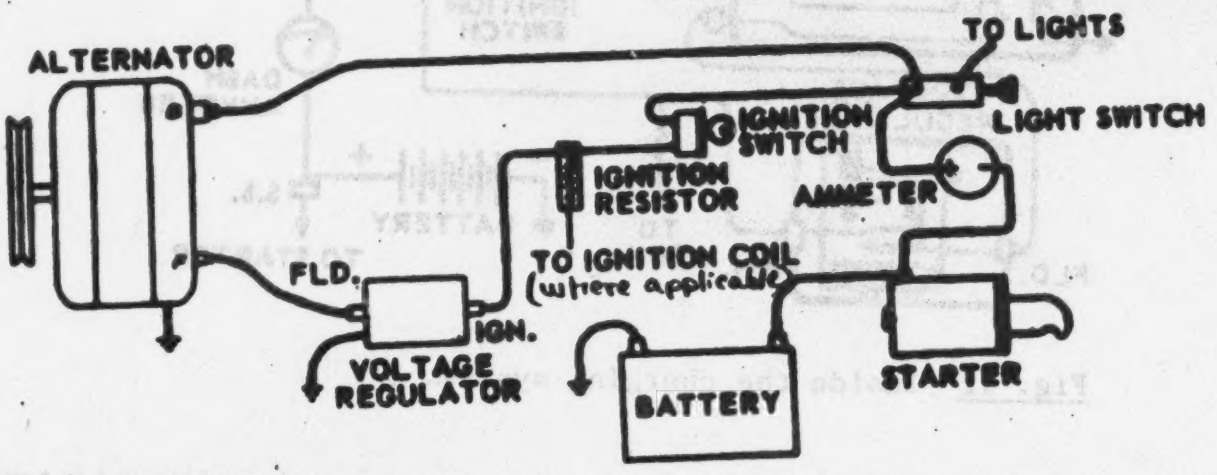


Fig. 11 Charging System.

For many years, all automotive generators were direct current (DC) units. In recent years, alternating current (AC) generators, or alternators, as they are also called, have come into widespread use. Direct current flows in one direction only, and alternating current flows first in one direction and then the other. Vehicles equipped with batteries are not able to use alternating current. The alternating current developed in the alternator is rectified (changed to DC current).

The alternator has proven to be more efficient, even at low engine speeds. Most alternators have built in rectifiers consisting of diodes. The diode is an electronic device that permits current to flow in one direction only. A three phase AC generator (alternator) developing 12 volts would have six diodes, three positive and three negative, see Figure 12. Diodes are usually mounted in the slip ring end of the alternator, in a metal bracket called a heat sink. The heat sink absorbs heat from the diodes, which become rather hot in operation. The shape of the heat sink, with large radiating surfaces, allows the heat to be radiated into the surrounding air. The diodes do not overheat under normal operating conditions.

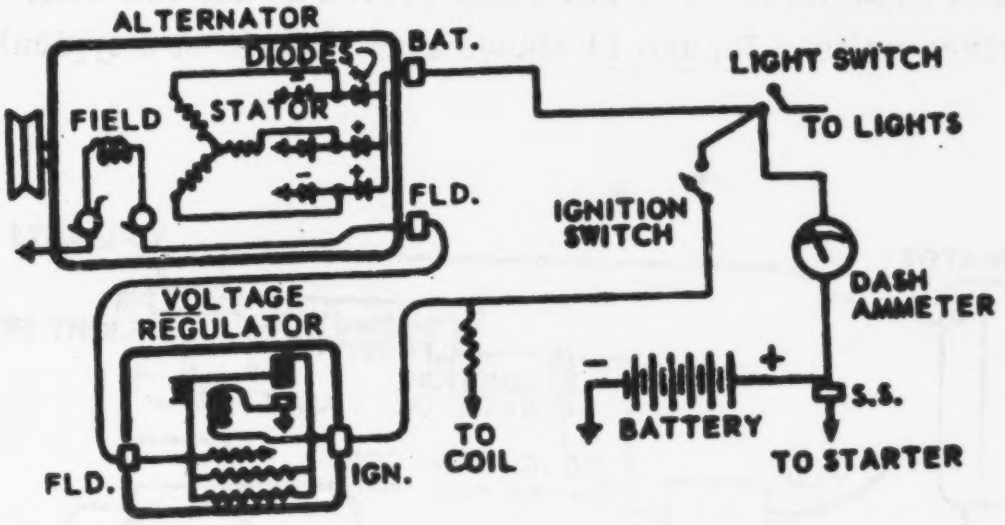


Fig. 12 Inside the charging system.

SECTION B -- REGULATING THE GENERATOR/ALTERNATOR

NEED FOR REGULATION -- Both AC and DC generators require regulation, and both achieve regulation in the same manner: by limiting the amount of current flowing in the generator field winding (or windings). By "regulating" we mean preventing the generator or alternator from producing excessive voltage and current.

Without regulation, a generator or alternator would continue to increase its output as speed went up until it would be producing so much current it would overheat and burn up.

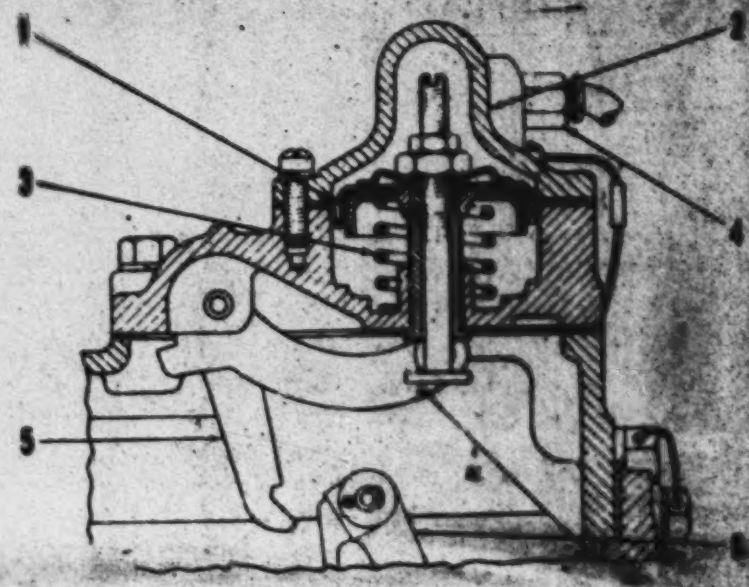
The DC generator uses an external resistance to control generator voltage and amperage output.

A variety of regulating devices are used to regulate AC generators. Essentially, regulation is accomplished in the same way as for DC generators: by placing resistance in the generator field circuit. There are some peculiarities of AC circuits, however, that merit special attention. Some AC generator stators remain permanently connected to the battery, through the diodes, so that no cutout relay is needed. The diodes prevent the battery from discharging back through the stator windings when the engine is not running. Some systems use only a voltage regulator for generator control. Some regulators use transistors.

This has been a very brief description of one type of a charging system used on vehicles. Later on when we get into electrical, this subject will be covered in great detail.

SECTION C -- CHARGING SYSTEM SERVICE PRECAUTIONS

1. Always be absolutely sure that the battery ground polarity and the charging system polarity are the same, when installing a battery.
2. Do not polarize an alternator.
3. Never short across or ground any of the terminals on either the alternator or the regulator.
4. Do not operate an alternator on open circuit.
5. Booster battery must be correctly connected.
6. Battery charger must be correctly connected.
7. Always disconnect the battery ground cable before replacing or servicing electrical units.



1-Diaphragm. 2-Chamber. 3-Spring. 4-Fitting.
5-Bellcrank. 6-Linkage.

Rack Limiter (engine not running) (limiter inoperative)

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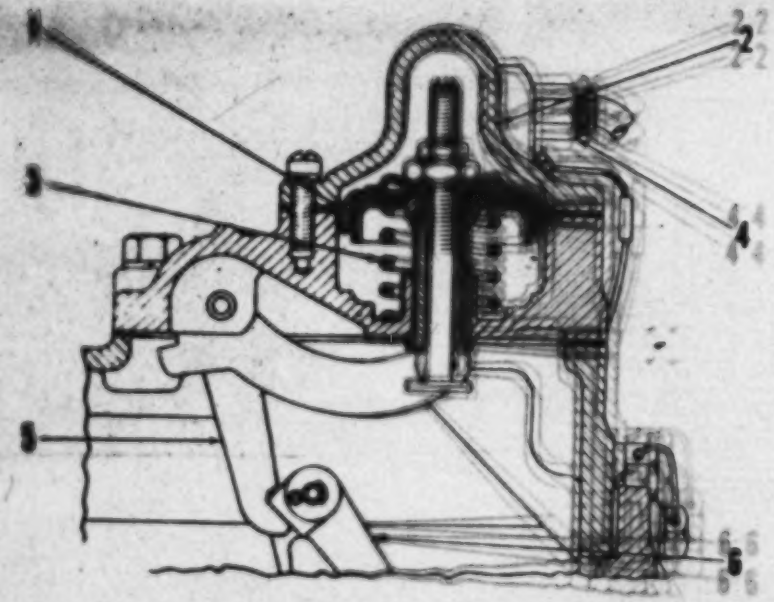
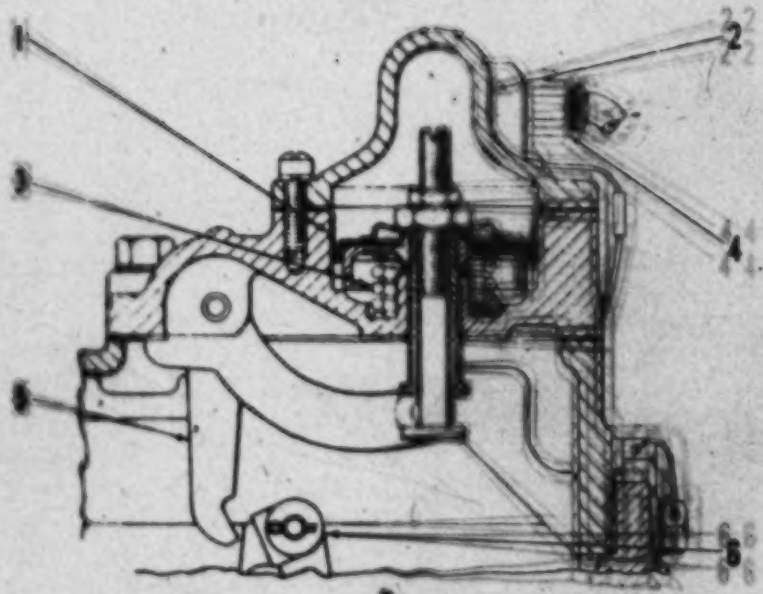


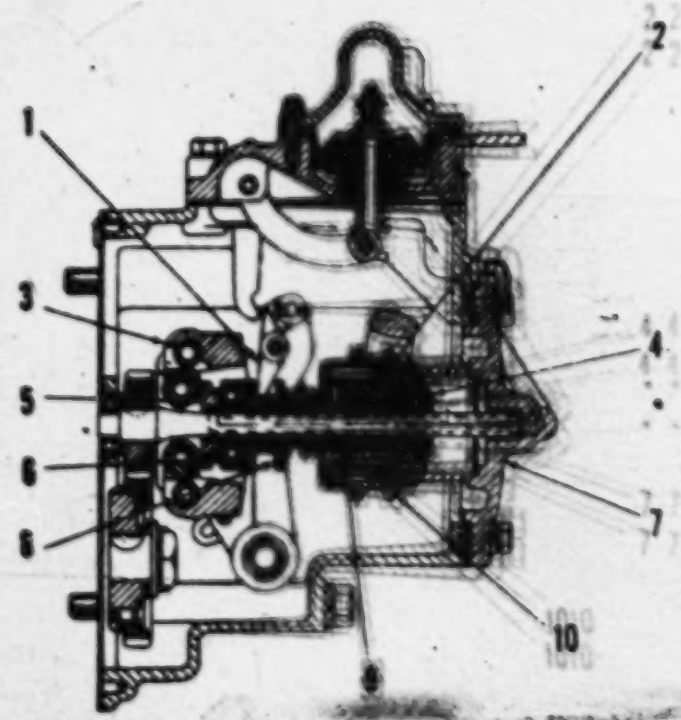
1-Diaphragm. 2-Chamber. 3-Spring. 4-Fitting.
5-Bellcrank. 6-Linkage.

Rack Limiter (engine under acceleration)
(limiter restricting fuel rack opening.)



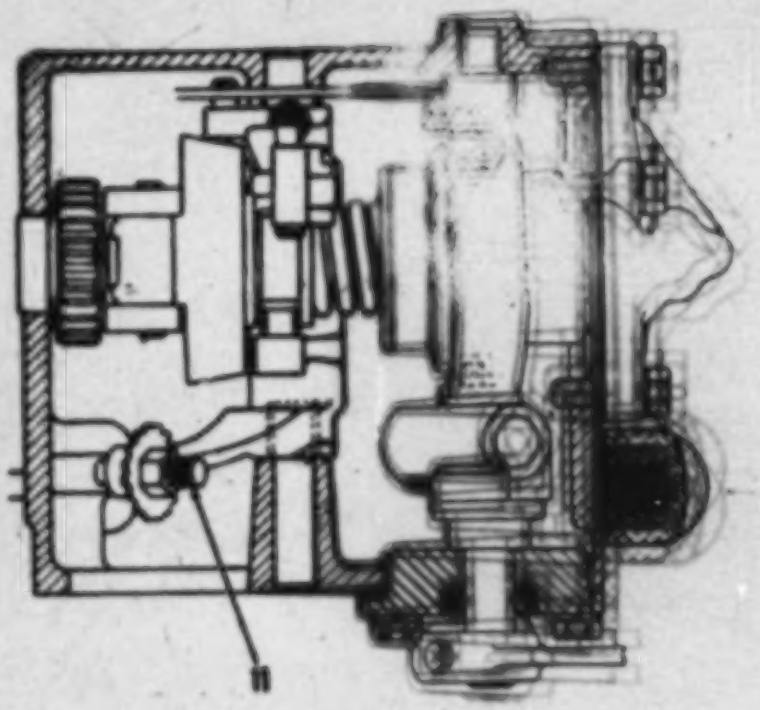
1-Diaphragm. 2-Chamber. 3-Spring. 4-Valve. 5-Bellcrank. 6-Linkage.

Rack Limiter (engine under full load) (Governor has full control).



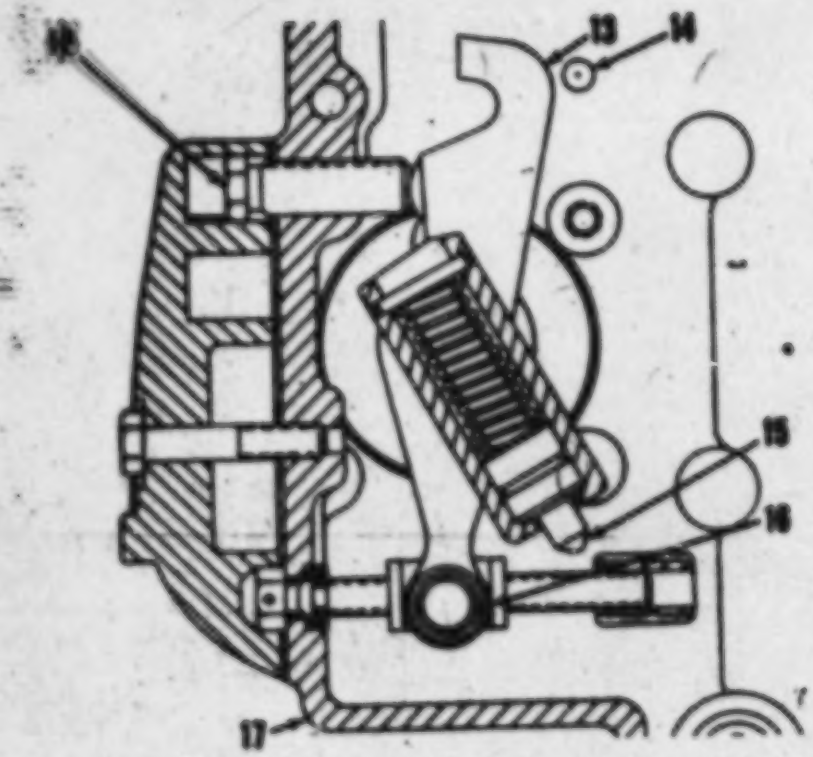
1-Fuel pump rock assembly. 2-Springs (two). 3-Weight.
4-Piston assembly. 5-Sleeve assembly. 6-Bearing.
7-Cover. 8-Cage. 9-Spindle. 10-Cylinder.

Fig. 5 Governor cross section (right side view)



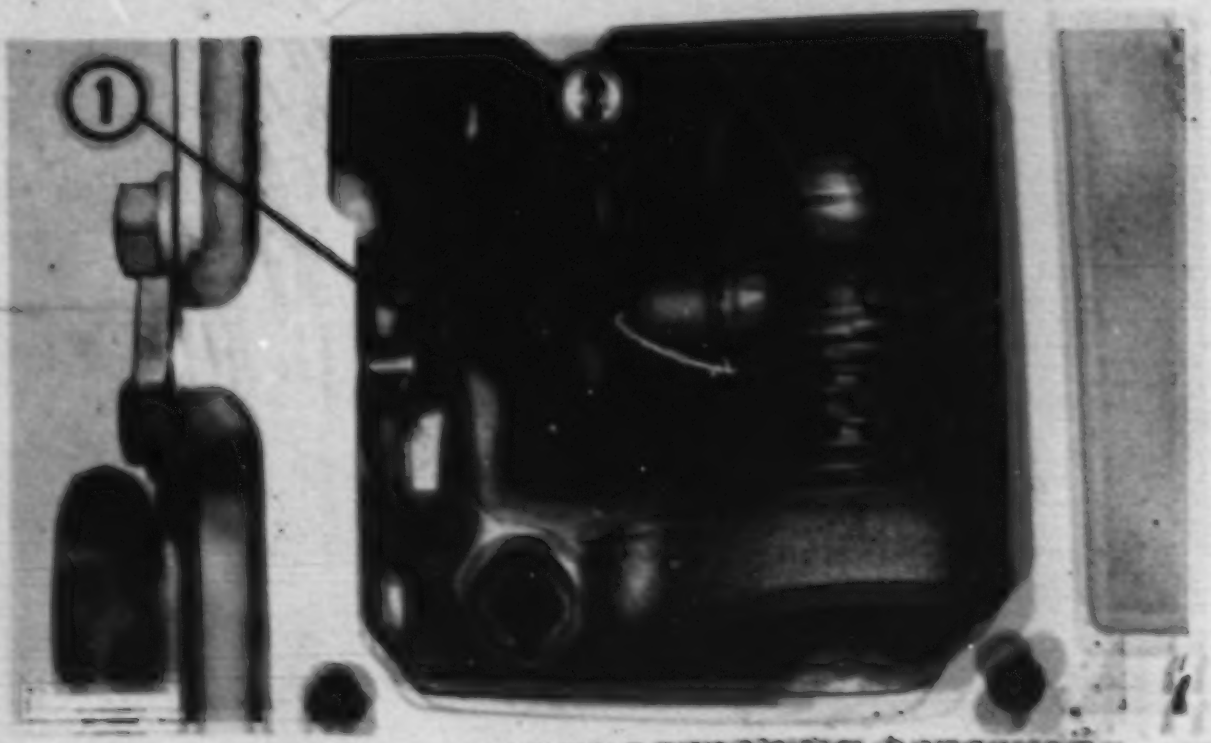
11-Adjusting screw.

Fig. 4 Governor Cross Section (top view).



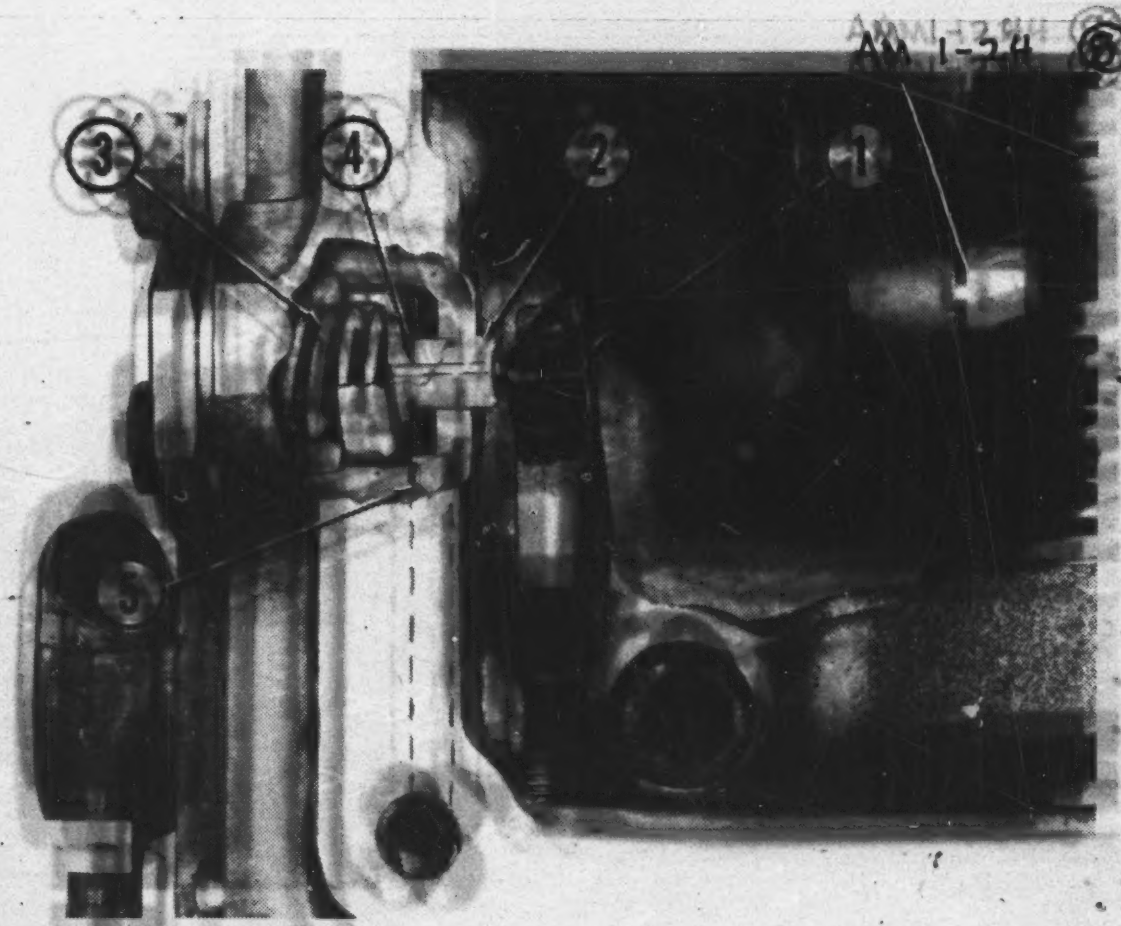
13-High idle adjusting screw. 13-Stop. 14-Speed limiter plunger. 15-Plunger. 16-Roller. 17-Governor housing.

Fig. 7 Governor Shaft Section (partial left side view).



SPEED LIMITER — BELOW OPERATING PRESSURE

1–Stop. 2–Plunger.



SPEED LIMITER — OPERATING PRESSURE
1–Stop. 2–Plunger. 3–Spring. 4–Drilled hole. 5–Oil supply passage.

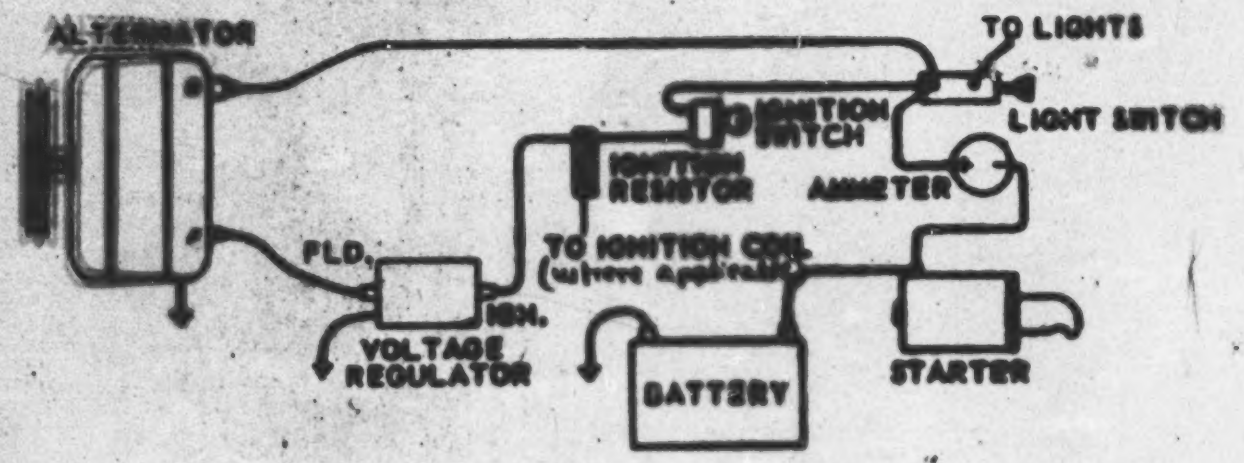


Fig. 11 Charging System.

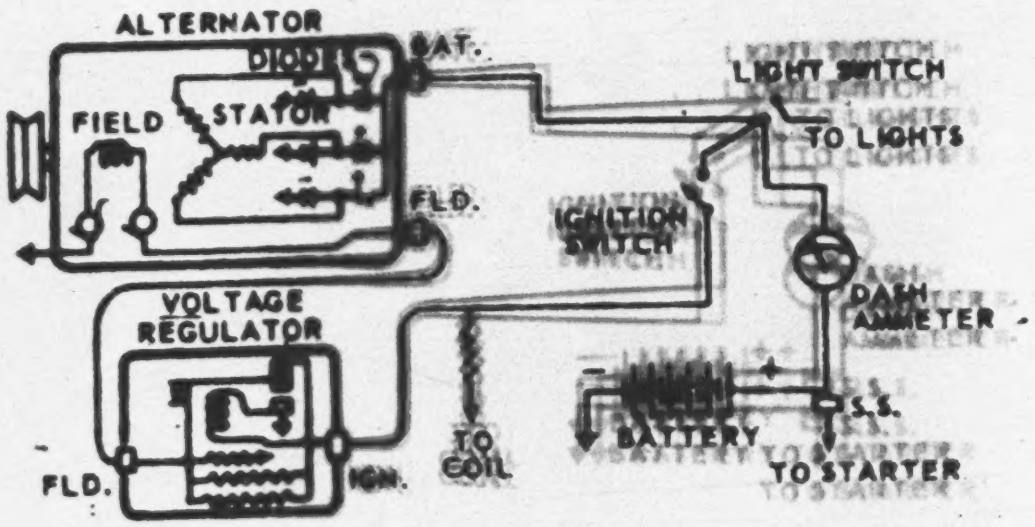


Fig. 12 Inside the charging system.

INSTRUCTOR'S GUIDE

Title of Unit: I -- MAINTAINING THE FUEL SYSTEM (PART III) -- CATERPILLAR DIESEL ENGINE
II -- UNDERSTANDING THE VOLTAGE REGULATOR & ALTERNATOR

AM 1-24
8/16/66

FIRST: Be sure all questions have been answered that students might have on home study units.

OBJECTIVES:

1. To continue the discussion of the CAT fuel system by covering injection timing controls, how they function, how they fit into the system, and their location.
2. To introduce, in the second part of this unit, a discussion of a charging system. This is meant to be brief and give the student just enough to wet his appetite for more.

LEARNING AIDS suggested:

Vue Cells:

AM 1-24 (1) (Rack Limiter - Engine not running)
AM 1-24 (2) (Rack Limiter - Engine under acceleration)
AM 1-24 (3) (Rack Limiter - Engine under full load)
AM 1-24 (4) (Governor Cross Section - Right side view)
AM 1-24 (5) (Governor Cross Section - Top View)
AM 1-24 (6) (Governor Cross Section - Partial left Side view)
AM 1-24 (7) (Speed Limiter - Below Operating Pressure)
AM 1-24 (8) (Speed Limiter - Operating Pressure)
AM 1-24 (9) (Charging System)
AM 1-24 (10) (Inside the Charging System)

MODELS:

Any components of the CAT fuel system that can be brought to class will help in explaining and demonstrating the subject. For the latter part of this unit, an alternator and voltage regulator would be helpful.

QUESTIONS FOR DISCUSSION AND GROUP PARTICIPATION:

1. What is the CAT Speed sensing variable timing unit used for?
2. What is a CAT rack limiter? How does it work?
3. How does speed of the turbocharger affect the rack limiter?
4. Where is the CAT governor located? How is it driven?
5. Is the CAT governor discussed in this unit partially hydraulic? Explain.
6. Is the governor lubricated? How?
7. What is the speed limiting device on a CAT? How does it work?
8. Could an alternator be called an energy conversion unit? Explain.
9. How is current changed in an alternator?
10. What is the purpose of a voltage regulator?